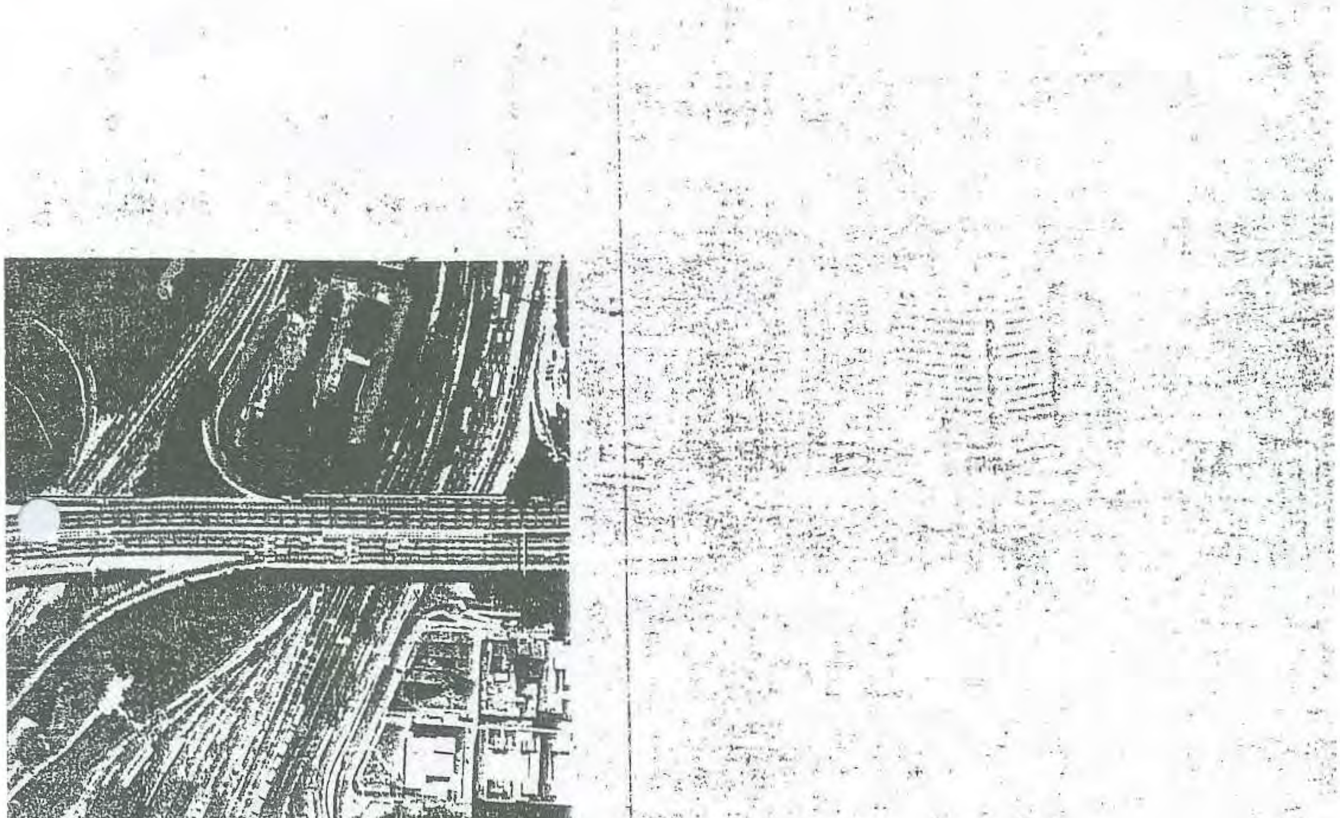
The Professional Journal Of The Institution Of Surveyors Malaysia

THE SURVEYOR

LAND SURVEYORS, QUANTITY SURVEYORS, GENERAL PRACTICE SURVEYORS & BUILDING SURVEYORS



Volume 28 No 3 3rd Quarterly 1993 PP735/3/93 ISSN. 0127-4937

Effects of Cement — Rice Husk Ash Mixtures On Compaction, Strength And Durability of Melaka Series Lateritic Soil

by

Megat Johari Megat Mohd Noor
Azlan Abdul Aziz
Radin Umar Radin Suhadi
Dept. of Civil & Environmental Engineering
Universiti Pertanian Malaysia, Serdang.

ABSTRACT

An experimental investigation into the effects of various rice husk ash-cement proportions on some geotechnical properties for road construction of a lateritic soil, Melaka Series, was made. The influences of different mix proportions of cement and RHA on compaction characteristics, soaked and unsoaked unconfined compressive strength, tensile strength and durability were studied. Test results show that the Melaka Series stabilized with cement and rice husk ash mixtures can be used for lightly trafficked or rural roads if the loading capacity is controlled initially for 28 days. Durability characteristics achieved satisfy recommended values.

INTRODUCTION

Compaction of materials in pavement construction is normally achieved through mechanical means. It allows rapid reduction in voids volume through expulsion of air from voids and thus enables higher density and strength to be achieved. Physical stabilization may also be employed together with mechanical compaction if the strength requirement is not met mechanically.

Stabilizing agents such as cement, asphaltic cement, lime and ash are the possible alternatives in physical stabilization. As an example, cement is known to create bonding in concrete through hydration. The pozzolanic reaction of rice husk ash (RHA) obtained under controlled incineration conditions is far superior to any of the known pozzolanic materials (1). Thus low quality materials or insitu materials can be improved to satisfy the requirement. The use of these additives are applicable especially when there is inavailability of suitable base material or unsuitability of subgrade strength for pavement construction. In Sabah, the North and Labuk Roads in Sandakan utilized soil cement in place of mine gravel which are very expensive. The soil was obtained from burrow areas along the road with 60% fines (i.e. passing 70 μm) (2). Existing earth roads may also be upgraded through this mean.

More than half the area in Peninsula Malaysia is covered with residual sedimentary rock soil rich in iron and alumina content which give its lateritic nature (3). A Study was conducted on a lateritic soil, Melaka Series, to obtain the effects of physical and mechanical stabilization on strength development and durability. The additives used were cement and RHA. Previous work showed significant improvement of the soil unconfined compressive strength value from 0.3 MN/m^2 to 1.7 MN/m^2 with 10% cement content (4). The strength value is close to the recommended 1.72 MN/m^2 for base material in road construction suggested by Andrew (5). Currently the strength requirement has been increased to 2.8 MN/m^2 to satisfy the increase in traffic in the United Kingdom (6). The addition of cement and RHA blend is expected to improve the strength since RHA is noted for its highly active silica content which will react slowly with lime to bind the material. Blending of cement and ash-cement (Lime-RHA) is shown to have improved the strength (1). It is also envisaged that RHA as an agricultural waste product can be usefully disposed of with utilization.

MATERIALS AND METHODS

The materials used in this study were lateritic soil of the Melaka Series (8), rice husk ash and Ordinary Portland Cement. Physical properties of the soil is as shown in Table 1 and were obtained in accordance with BS 1377 (7). The RHA was obtained from an open burning site. The chemical composition and properties of RHA have been studied by Cook (18) and is reproduced in Table 2.

KEYWORDS: Soil Cement, Ash-Cement, Rice Hush Ash, Soil Stabilization, Lateritic Soil.

Various laboratory tests were performed on the Melaka Series with different mix proportions of soil, RHA and cement in the ratio 100:0:0; 90:10:0; 85:10:5; 80:10:10 and 75:10:15. These ratios are based on the total dry weight of the required sample. The method of proportioning adopted is similar to current concrete mix design method and is also more meaningful than expressing the percentage additive as the percentage of the dry soil mass, as the proportion of cement and RHA required for a given volume of road to be constructed can then be calculated directly.

Standard Proctor compaction and unconfined compression tests were carried out in accordance with BS 1924 (9). The split cylinder (tensile test); and wetting and drying test (durability test) carried out are in accordance with BS 1881 (10) and ASTM (11) respectively except for the specimen size of the durability tests. All specimens used in the compression, tensile and durability tests were compacted at the Proctor optimum moisture content. Cement, RHA and the soil were mixed thoroughly and uniformly by hand at the predetermined moisture content.

A set of 12 specimens from each soil, cement and RHA ratio was tested for each strength and durability tests. The dimension of each specimen were 200mm height x 100 mm diameter. All specimens were cured (by waxing) at room temperature for 7 days before being loaded in compression for their respective 7 day unconfined compressive strength (UCS), 28 day UCS, 7 day soaked UCS, tensile stress and the UCS after 9 cycles of wetting and drying. Only 9 cycles of wetting and drying were carried out for the durability tests as the occurence of adverse deformation beyond 9 cycles would render comparative strength values if obtained to be worthless.

TABLE 1
Properties of original Melaka Series

Properties	*Results*
Natural MC (%)	17
Liquid limit (%)	47
Plastic limit (%)	26
Plasticity index (%)	21
Maximum dry density (Mg/m^3)	1.42
Optimum moisture content (%)	28
% passing No. 200 BS sieve	62
Specific gravity	2.64
Unconfined compressive strength (MN/m^2)	0.2
Unified soil classification system	CL

RESULTS AND DISCUSSION

Physical properties of Melaka Series

General properties of the lateritic soil used were determined and are summarised in Table 1. The particle size distribution curve is as shown in Fig. 1. It should be noted that although the soil is classified as a silty clay (CL), when employing the Unified Soil Classification System, appreciable amount of

TABLE 2
Chemical composition and physical properties of rice husk-ash (Cook, 1976)

Silicon dioxide (SiO_2), %	92.995
Other oxides, (%)	3.818
Loss of ignition, (%)	2.932
Blaine fineness, (cm^2/g)	12.500
Specific gravity	2.36

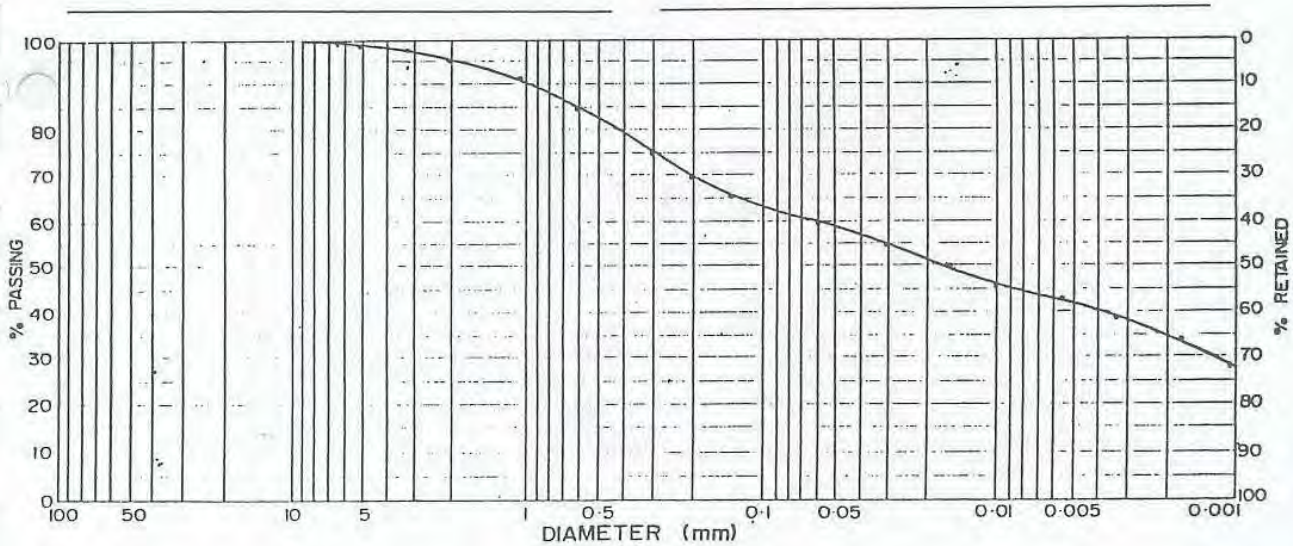


FIG 1 : Particle Size Distribution of the Melaka Series

sand and gravel i.e. 40% is present. Ting (12) used the term sandy silty clay to describe such a material. The plasticity index was found not to be a significant parameter but rather the appreciable presence of sand and gravel have a significant effect on the strength (12). It should also be noted that the percentage passing No. 200 sieve is above the generally recommended less than 40% for cement stabilisation (13). The liquid limit and plasticity index however satisfy the respective requirements of less than about 45 – 50 and less than 25 (13)

Compaction Characteristics

Results of the compaction tests are summarised in Table 3. The trend in changes of optimum moisture content and maximum dry density of the soil with various rice husk ash content for a constant cement mix of 10% is shown in Fig. 2. It can clearly be seen that the optimum moisture content increases while the maximum dry density decreases with increase in RHA contents. These results affirm the findings of previous work done on Nigerian lateritic soil (14). The presence of RHA in soil-cement mixtures may therefore be used in areas where the natural water content is much higher than the optimum moisture content based upon its ability to hydrate the water content.

TABLE 3
Effects of cement-RHA mixtures on compaction characteristics of Melaka Series

Ratio of mix % soil : % cement : % RHA	OMC (%)	γ_d (Mg/m^3)
100 : 0 : 0	30	1.417
90 : 10 : 5	28.5	1.454
85 : 10 : 5	29.5	1.430
80 : 10 : 10	31.0	1.380
75 : 10 : 15	31.0	1.320

Strength Characteristics and Durability

The mean UCS at 7 day, 28 day and 7 day soaked condition together with tensile strength from split cylinder tests at various soil-cement-RHA proportion is as shown in Fig. 3. It can be seen that the dry strength of the soil without any stabilizing agent hardly achieve 0.2 MN/m^2 while at 10% cement content. significant improvement in strength of above 1.5 MN/m^2 was achieved i.e. approximately 8 times. Addition of RHA i.e. at 5% showed a slight increase to approximately 2.6 MN/m^2 and further increase in RHA content is not significant in strength development. The 28 day UCS follows closely the trend set by the 7 day UCS. All the specimens satisfy the 1.72 MN/m^2 criterion for base materials in road construction after 28 days. Constructed lateritic roads of the Melaka Series stabilised with cement and RHA having initial lower UCS values can therefore achieve the criteria if the loading capacity is regulated.

The maximum soaked UCS is achieved at 1.4 MN/m^2 for a 10% addition of RHA. The saturated specimens, as expected, showed a reduction in strength varying between 20 – 30% in comparison to the dry strength of the soil. RHA addition or greater than 10% does not contribute to improvement in strength and in fact the dry density drops rapidly.

The tensile strength of the soil is unexpectedly not affected by the increase in RHA content. The split cylinder test is not sensitive enough to record the differences. William (6) mentioned that direct tensile test is a more accurate method but is still being developed. Insignificant increase in strength from the addition of RHA could be due to moisture absorption which render it to be inactive or due to insufficient presence of lime in the cement. Allen (15) mentioned that RHA exposed to the environment can result in the loss of binding capacity. Even so, there is an increase in strength at low RHA content which could be explained by the well distribution of cement attained from the cement-RHA blend. Although the density of the sample is reduced with addition of RHA, there is no significant reduction in strength at low percentage. RHA can thus be regarded as a useful additive.

The cumulative losses of weight of the soil obtained from the wetting and drying test is shown in Fig. 4. The loss associated with no addition of RHA after the ninth cycle is less than 1%. Jais (16) carried the test on the sample of soil up to the twelfth cycle and found that the the cummulative losses incurred is 1%. With 5% addition of RHA, slightly higher losses is obtained after 9 cycles. The 10% addition of RHA recorded 3% losses at the same cycle. All losses stated are less than maximum allowable values of weight loss as cited by Mitchell (17) for soil stabilised with cement. The UCS obtained after the ninth cycle (in Fig. 5) showed that the soil-cement mixture is higher than all of the RHA varied specimens. This confirms the earlier expectation that the RHA does not enchance binding within the matrix of the stabilised material. Addition of lime and/or freshly prepared RHA may improve the RHA binding capacity.

Nevertheless the RHA is still useful, as stated earlier, as it enhances cement distribution. Infact, cement content may be reduced further without any danger of rapid strength reduction for soils which require less cement to satisfy the strength limit. The lower the cement content the more difficult it is to ensure thorough mixing.

CONCLUSIONS

The following conclusions can be made based on the test result obtained from the cement-RHA stabi-

lised Melaka Series lateritic soil:

(i) The properties of Melaka Series lateritic soil although not fully satisfying the requirements for stabilised soil can with the aid of rice husk ash achieve strength and durability criteria for low trafficked or rural roads.

(ii) The 1.72 MN/m^2 criterion for base materials of roads can be satisfied if the loading capacity is regulated. This is easily achieved for roads with low volume of traffic.

(iii) RHA when used as an alternative or as a partial replacement of cement in stabilizing lateritic soil can reduce the cost of material for construction as well as solving the disposal problems.

(iv) Losses associated with durability test has been found to be very much less than recommended maximum allowable values.

REFERENCES

1. LAURICIO, F.M., Technology Manual on Rice-Husk Ash Cements, UNDP/UNIDO Regional Network in Asia for Low Cost Building Materials Technologies and Construction Systems.

2. SHAIK ABDUL WAHED, Geotechnical and Environmental Associates Sdn. Bhd., Personal Communication (1988).

3. Aun, O.T. Malaysian Soils and Associated Problems, *Geotechnical Engineering Course*, Universiti Malaya, (1982).

4. MEGAT JOHARI MEGAT MOHD NOOR and AZLAN ABDUL AZIZ, Soil Cement for Low Cost Roads, *Proceedings of the 14th WEDC Conference* Kuala Lumpur, (1988).

5. ANDREWS, W.P., Soil Cement Roads, Cement and Concrete Association, 3rd (Revised Edn, Slough, UK) (1955).

6. WILLIAMS, R.I.T., Cement-Treated Pavement, Elsevier Applied Science Publisher, London (1986).

7. BRITISH STANDARD INSTITUTION, BS 1377 Methods of Test for Soils for Civil Engineering Purposes, London (1975).

8. PARAMANATHAN, S. S. JUSOP and N.M. NIK WAN, Soil Map of Universiti Pertanian Malaysia Farm, *Bulletin Teknikal Fakulti Pertanian* (1979).

9. BRITISH STANDARD INSTITUTION, BS 1924 Methods of Test for Stabilized Soils, London (1975).

10. BRITISH STANDARD INSTITUTION, BS 1881: Part 4 Methods of Testing Concrete for Strength (1970).

11. AMERICAN STANDARD TESTING AND MATERIALS, ASTM, D 599, Wetting and Drying Test of Compacted Soil-Cement Mixtures (1982).

12. TING, W.H., Some Aspects of Soil Stabilization in West Malaysia, *Journal of Institution of Engineers Malaysia*, Vol 12 (1971).

13. DAS, B.M., Principles of Foundation Engineering, Brooks Cole Engineering Division, Monterey California (1984).

14. RAHMAN, M.A., Effects of Cement-Rice Husk Ash Mixtures on Geotechnical Properties of Lateritic Soils, *Soils and Foundation* Vol. 27 No. 2, Japanese Society of Soil Mechanics and Foundation Engineering (1987).

15. ALLEN, M.L., The Manufacture of a Cement Extender from Rice-Husks Using a Basket-Burner, Project Outline UNESCO (1988).

16. JAIS BASIRAN, Kajian Kemungkinan Simen Tanah Dengan Bahan Tambahan [Feasibility Study on Soil-Cement with Additives] Final Year BE Project, Universiti Pertanian Malaysia (1988).

17. MITCHELL, J.K., Lecture Notes for CE 272: Soil and Site Improvement Course, Dept. of Civil Engineering, U.C. Berkeley (1985).

18. COOK, D.J., R.P. PAMA and S.A. DAMER, Rice husk ash as a pozzolanic material, *Proceedings of Conference on New Horizons in Construction Materials*, Lehigh University (1976).

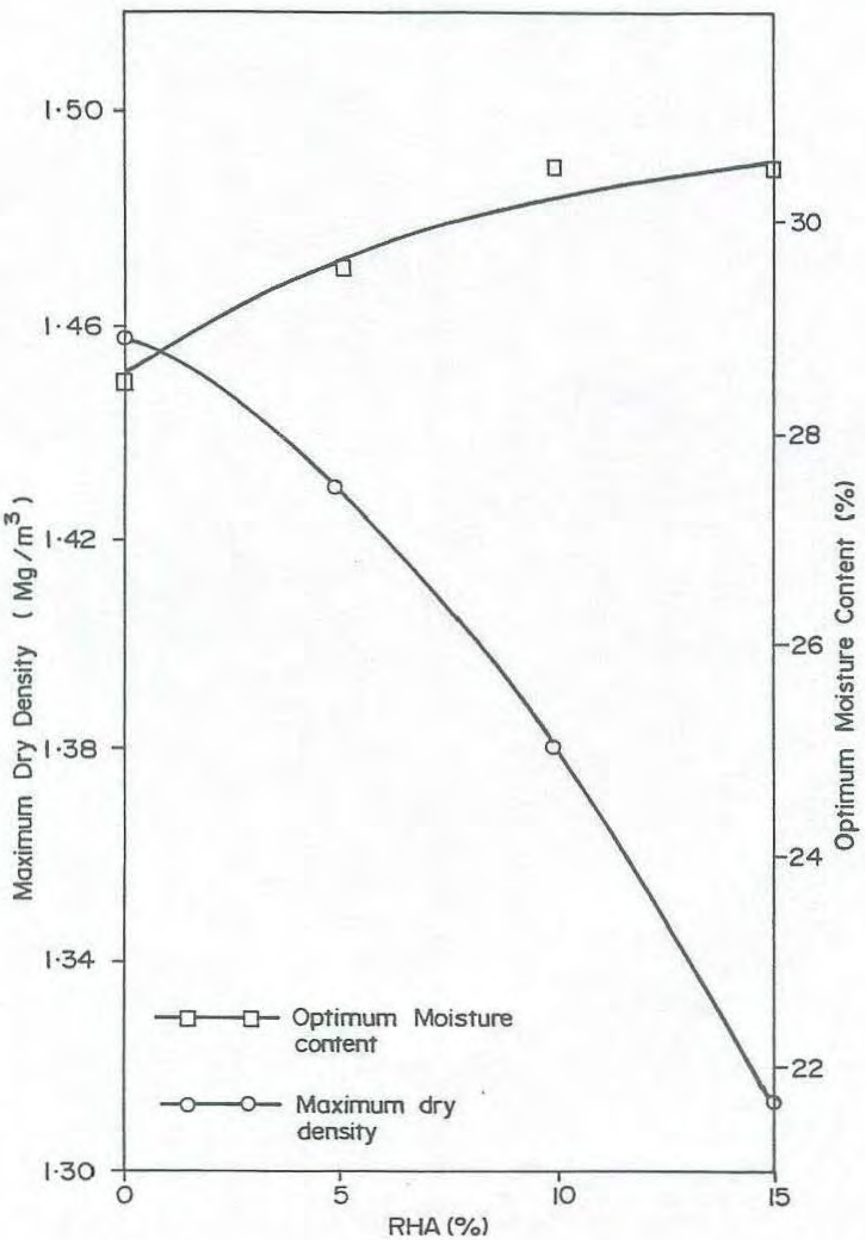


Fig.2 : Variation of Maximum Dry Density and Optimim Moisture Content with Varied RHA Content for Melaka Series with 10 % Cement Mix

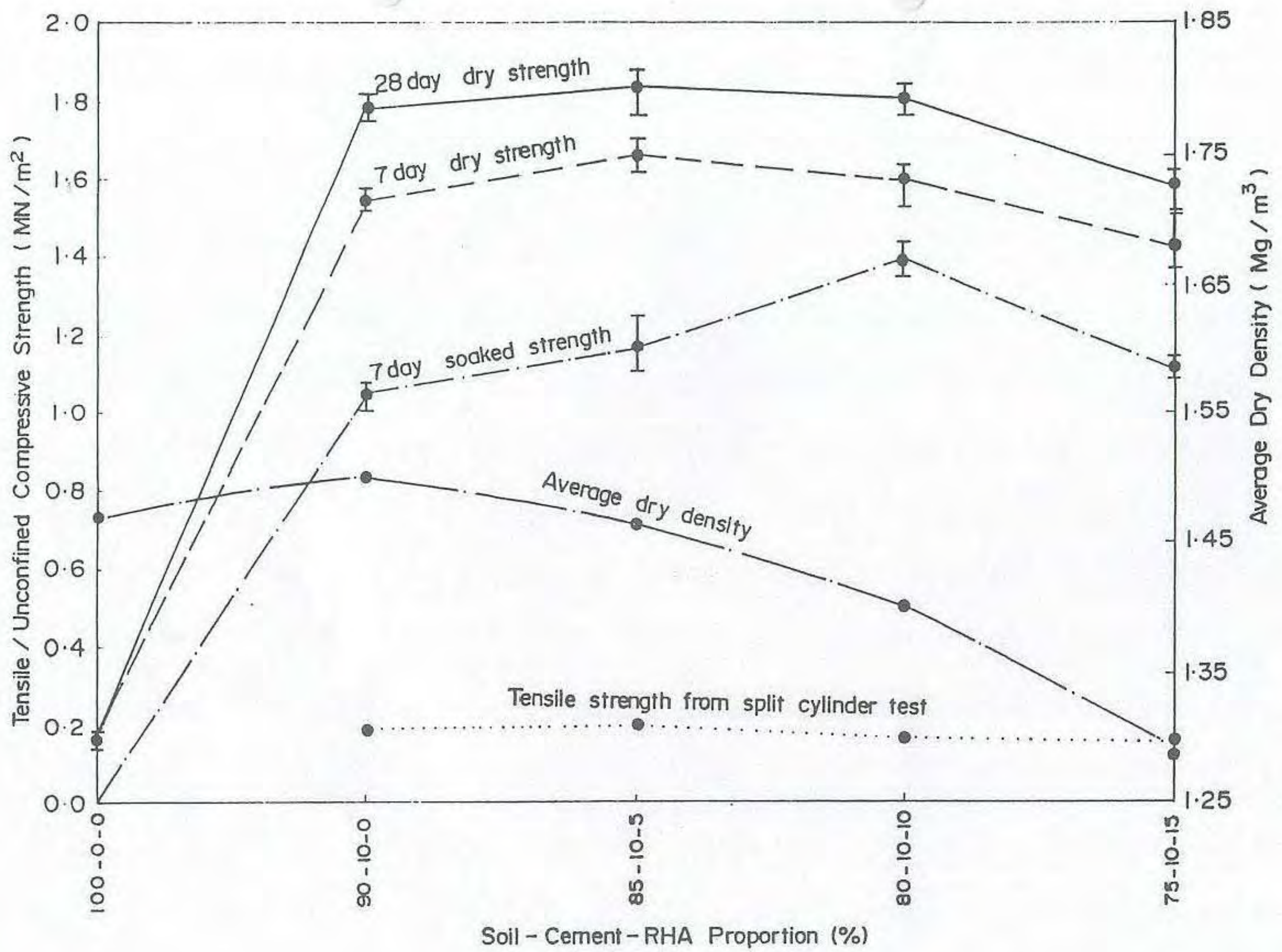


Fig. 3 : Relationship Between Tensile / Unconfined Compressive Strength (UCS) and Average Dry Density with Respect to Increase in RHA Proportion.

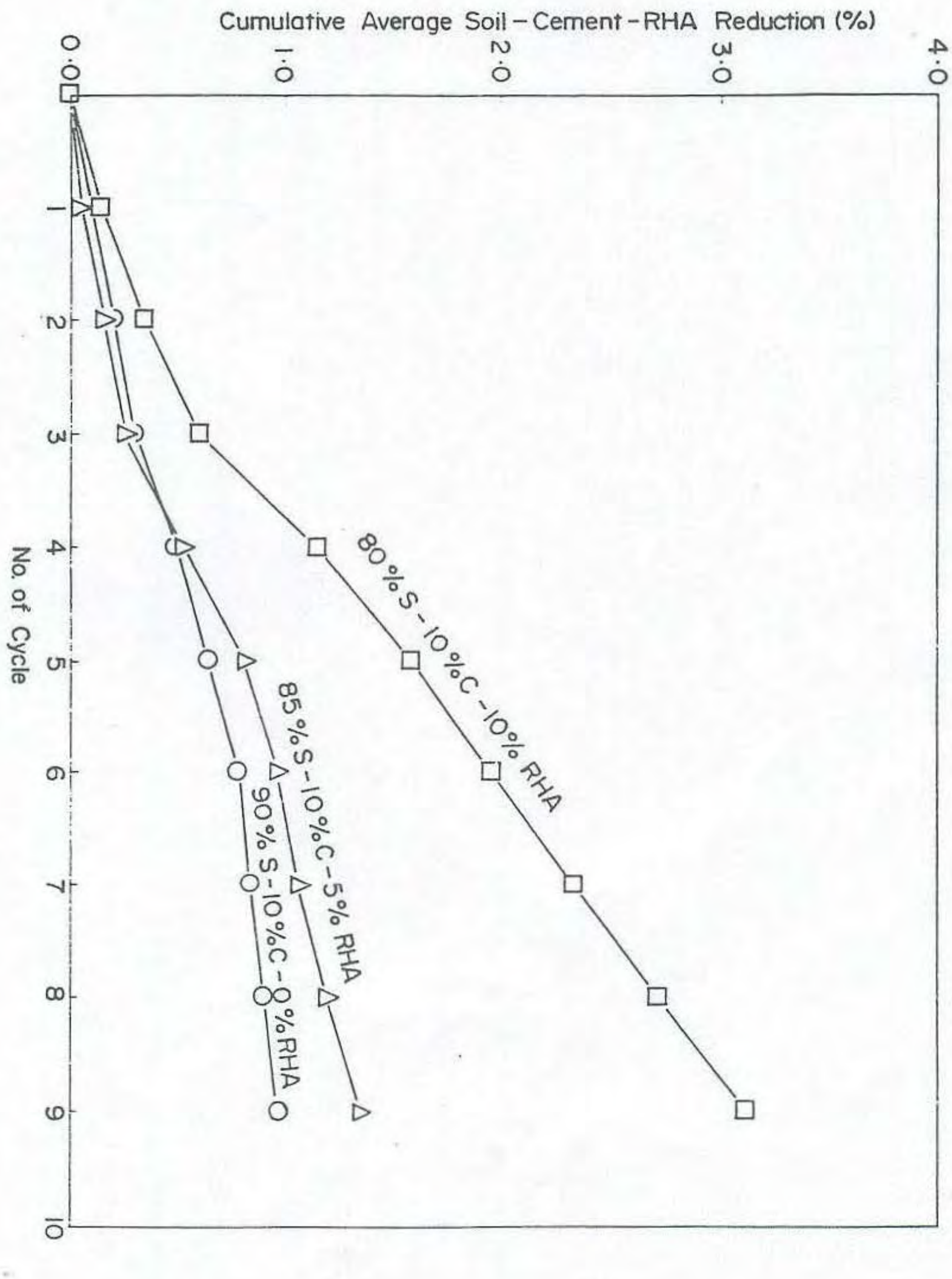


Fig. 4 : Cumulative Losses from Wetting and Drying Test